

## Forest Road Sediment Production Analysis Using Dynamic Segmentation

Dave LaPlante  
GIS/Database Administrator  
Northern California Resource Center

### Abstract:

Forest Road Inventory and Assessments have focused primarily on stream crossing evaluation. Recently, interest has turned to methods of defining hydrologic connectivity in the road system as an important element for evaluating potential impacts of forest road systems on fishery resources. This paper presents a GIS/database system and the associated field inventory used to document and manage a suite of point and linear events using dynamic segmentation at a one foot resolution. These derived spatial features are then used in an analysis of sediment production rates throughout the road system routed through a series of hydrologically connected events derived from the dataset and defined as network elements.

### Field Inventory:

The work discussed here has been developed on approximately 260 miles of private roads and public roads with cooperative easements in the Klamath region of Northern California. Although the National Forests have for a long time maintained data for their roads in the form of engineering road logs, private land management entities in this area traditionally have not.

To address this need, we have worked with the private land managers to design a comprehensive Road Inventory protocol used to develop the data necessary to support a detailed GIS database of all infrastructure elements within the road system. Those elements include both point and linear events, documented on a Road Log field form.

Traditional inventories have focused on stream crossing and erosion sites that directly deliver to the stream network, assessing both past and potential future erosion at those locations. In this inventory we document all sites with an erosion potential deliverable to the stream network (EPd) of 2 cubic yards or greater as well as all stream crossing using a comprehensive EPd Site Inventory form, which includes detailed information about the site and associated features, past erosion volumes and future potential erosion volume estimates, fill measurements and recommendations for mitigation. We also generate a diagram of the site showing all elements and processes, which are scanned in office, and capture digital images.

In addition to documenting basic infrastructure and erosion volumes derived from discrete erosion sites and stream crossing failure potential, there is an evolving need to define hydrologic connectivity along road alignments and the associated sediment production values. Rather than discrete event driven sedimentation, these hydrologically connected road segments represent chronic sediment sources on the landscape.

The Road Log form used is shown below. Point events are documented with a single record and code sets defining hydrologic network connectivity. Linear events are documented with a pair of records defining the FROM and TO end of the events, and coded to define both flow direction and hydrologic network connectivity. Measure values for each record are developed using a DMI calibrated to the vehicle, at a ± one foot resolution.

**COLLECTION POTENTIAL LINEAR EVENT:**

Features that potentially collect and convey water and sediment to streams

**CONTINUOUS LINEAR EVENTS:**

Values associated with Road Condition along continuous alignments

**POINT EVENTS:**

All features with a discrete location along the road. These include constructed elements as well as erosion and mass movement features.

Collection potential linear events include Inboard Ditches, Outer Berms, Ruts, and Grade Reversal slope events. Continuous linear events include road surface, shape, width and status fields. These elements represent values that will be overlaid with the collection potential linear events to derive sediment production values.

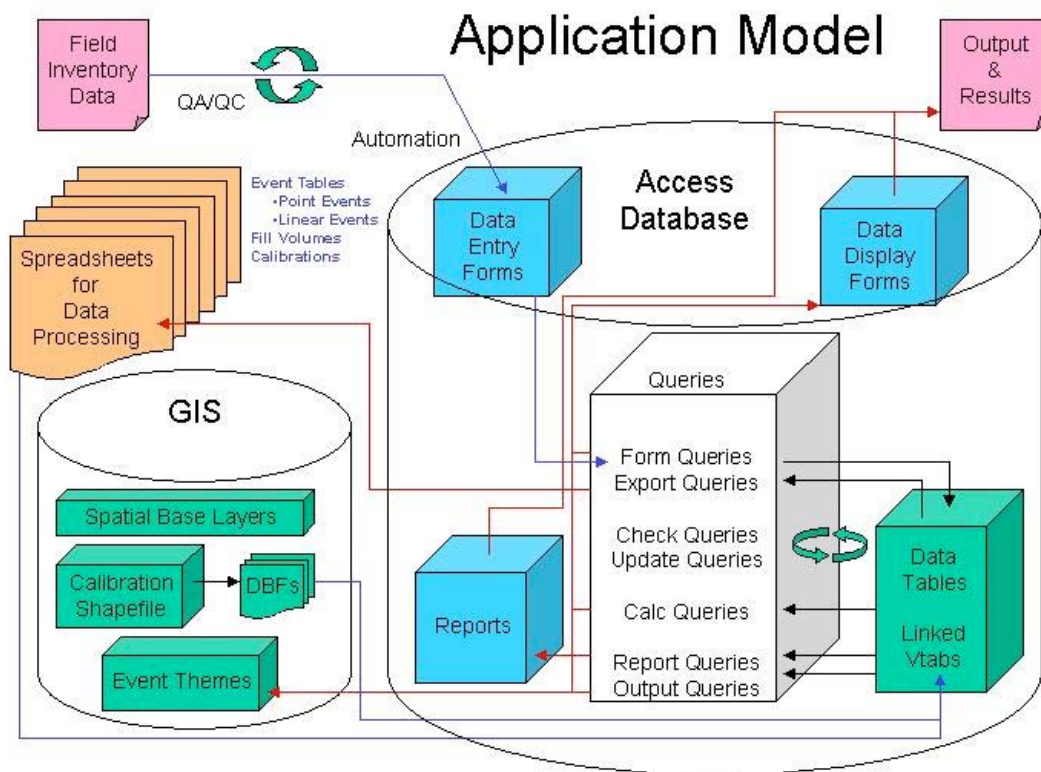
In addition to the suite of point and linear events described above, the code sets defining hydrologic network connectivity are used to generate network edge and junction elements that define the routing of sediment through the road system, effectively modeling the extension of the stream network up into and through the road system. Point event and linear event TO records are coded with an HC(<identifier>,<pass through>) value set that identifies the record the current record is hydrologically connected to, and the percent of conveyance that passes through that junction, or point of connectivity.

## Application Model:

Once field data has been captured and validated, it is automated into a Microsoft Access database that is integrated with the GIS and a suite of Microsoft Excel spreadsheets designed to calculate linear event records, fill volumes, and an array of supplemental derived result sets.

These data are then linked back into the application and processed through a suite of queries to derive a set of final event tables that are fed into the GIS and graphically rendered using linear referencing, and used for subsequent event on event overlays, as well as the suite of statistical reports produced from the inventory data.

Processing is automated and managed through a series of interfaces within the application.

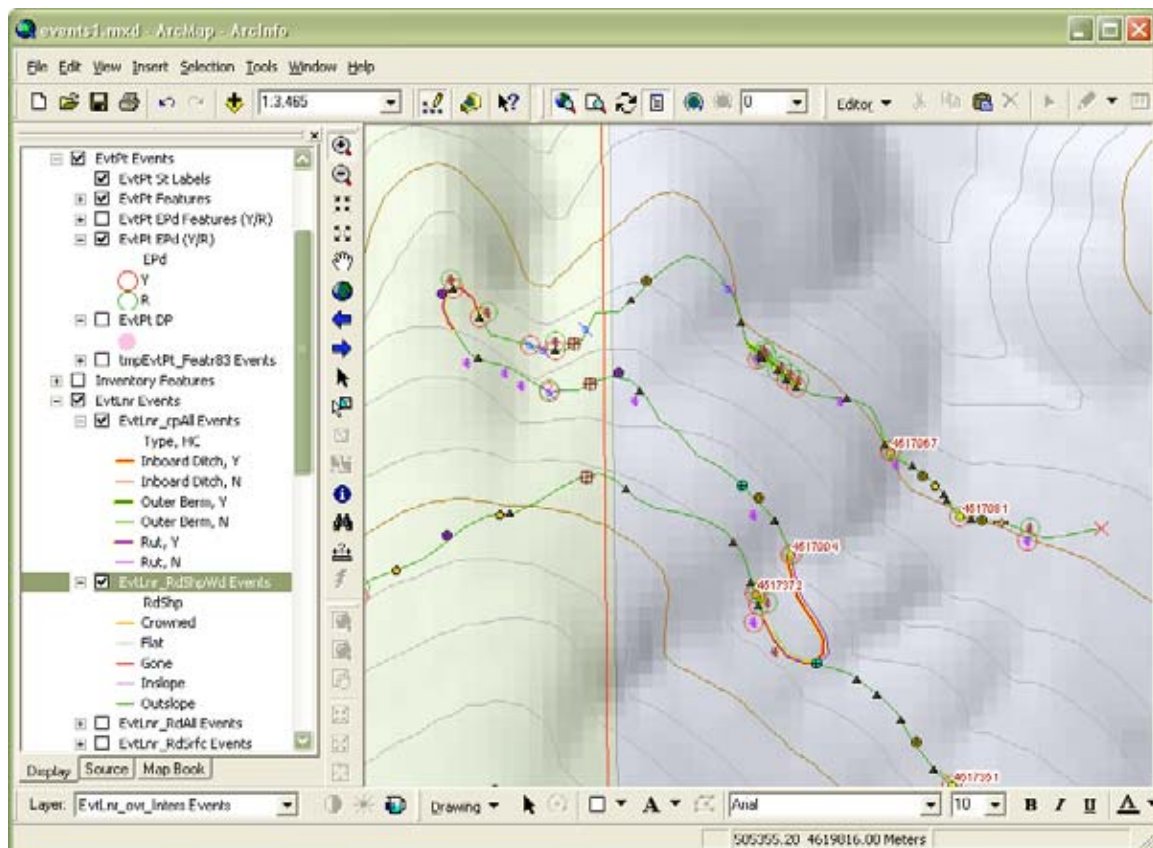


## GIS Processing:

Route data is initially developed in an ArcGIS 8.3 geodatabase, developed in a topologically integrated feature dataset comprised of road arcs, routes derived from the arcs, and controls derived from road system nodes and points of intersection with administrative boundaries, hydrography and synthetic streams.

A subset of the point event data for those controls are initially added into the GIS as used to calibrate the route system. Measure identification values from the point events are copied over to the controls using the attribute transfer tool. Once completed, the route system is calibrated using the ArcInfo Linear Referencing tools, added into and topologically integrated with the route feature dataset.

Once the routes are calibrated, point and linear event data can be added to the project. Event records processed in the application as sgl result sets are loaded into registered object tables in the geodatabase and used as the record source for route events.

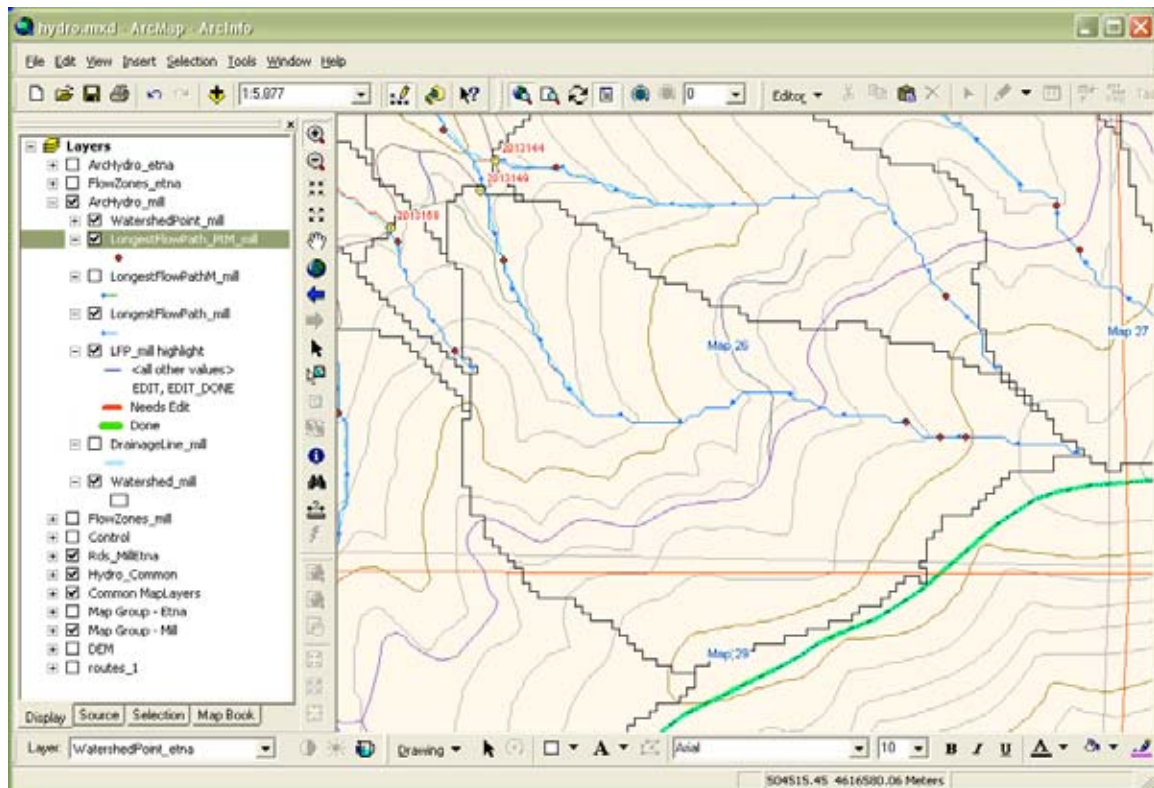


## Culvert Flow Design:

ArchHydro is used to develop watershed and longest flow path features used for culvert flow design analysis.

As a result of the precision in the inventory measure data, we are able to edit the hydrography to accurately model crossing locations, diversions and confluences. Once edits are complete, we use the Agree methodology to hydrologically correct the source 10 meter DEMs and force the synthetic stream network to reconcile with the field data.

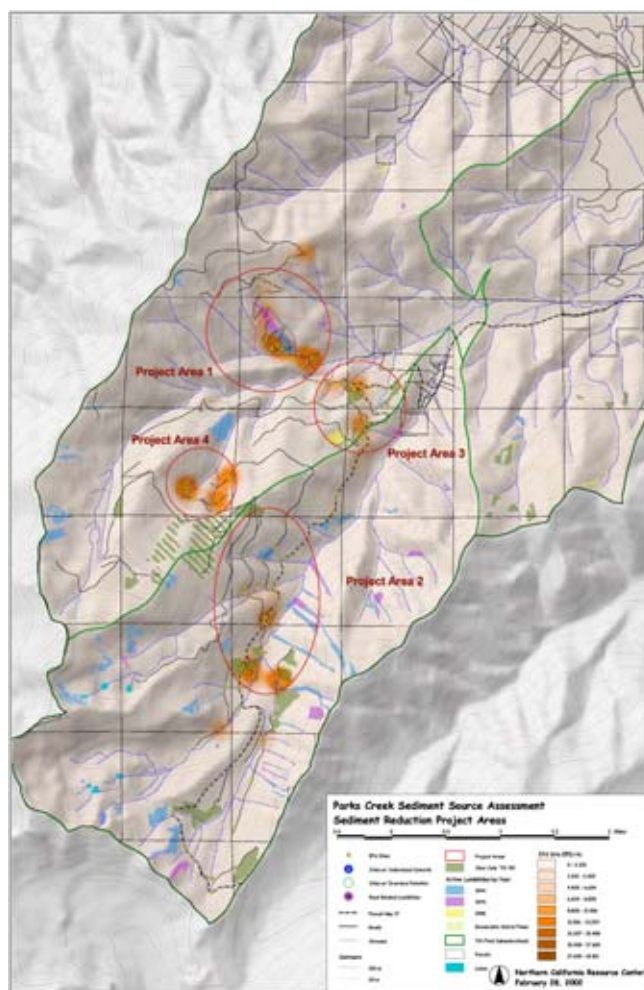
Pour point locations are then added as events calibrated to synthetic stream crossing locations, loaded into the Batch Watershed feature class, and used to derive the spatial feature that define the parameters for analysis (watershed areas, longest flow path, and points dynamically referenced at 10 and 85 percent the length of the longest flow path).



## Sediment Production Analysis:

Hydrologically connect collection potential events are processed using the ArcInfo Event Geoprocessing utility. Inboard ditches, outer berms, ruts and grade reversal events are first unioned with one another, then intersected with road surface, shape, width and status events to derive the result set used to calculate sediment production rates for hydrologically connected road segments.

Erosion volumes from point events and hydrologic linear events are then used with spatial analyst to create an accelerated sediment production surface to define areas in the study that require mitigation.



Project recommendations are then developed and assessed for cost effectiveness and benefit to in-stream resources.